

**DEVELOPMENT OF INSTRUMENTS AND  
TECHNIQUES FOR PULP EVALUATION  
SOME EFFECTS OF FIBER LENGTH AND CLAMPING  
CONDITIONS IN THE ZERO-SPAN TEST**

**Project 2406**

**Report Three**

**A Progress Report**

**to**

**MEMBERS OF GROUP PROJECT 2406**

**December 20, 1965**

THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

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SOME EFFECTS OF FIBER LENGTH AND CLAMPING CONDITIONS  
IN THE ZERO-SPAN TEST

SUMMARY

This report presents the results obtained in our continuing study on the instrumental and sheet variables in the zero-span test. The present study includes (1) an examination of the initial jaw separation with the idea of determining if the zero-span test is suitable for the evaluation of short-fibered pulps, and (2) an examination of the Britt-Yiannos technique to determine if the application of a "cushion" material (cellophane tape) to the jaw gripping surfaces results in improved specimen gripping conditions for a wide variety of pulps.

The results on initial jaw separation and fiber length show that the initial jaw separation becomes increasingly more critical with decreasing fiber length. A gumwood pulp was classified and for the fraction having a weighted average fiber length of 0.43 mm. (a length comparable to that encountered with some species of hardwoods), the results show that the zero-span tensile strength falls off sharply when the initial jaw separation exceeds about nine microns. This suggests that the zero-span test is applicable for the testing of short-fibered pulps but that good instrumentation with special emphasis on initial jaw separation, alignment, and cleanliness is required.

The results obtained with a cushion material in the jaws show evidence of improved specimen gripping conditions and are higher than those obtained with the bare jaws. The use of a cushion material apparently improves the distribution of the clamping load on the specimen and appears to minimize the adverse effects of local variability in thickness of the specimen. In contrast to the bare jaw

behavior, (where there was a plateau for basis weight from 40 to 70 g./sq.m.), the zero-span breaking lengths determined with a cushion increase with decreasing basis weight down to 12 g./sq.m.; at and below this basis weight, however, the reproducibility of the test falls off sharply. For tests made with a cushion in the jaws the basis weight will need to be controlled within fairly narrow limits for a valid comparison of pulp strength and it will be necessary to use a higher clamping pressure than previously recommended for the bare jaws. Tentatively, the use of a tape cushion, handsheets of a basis weight of 20 g./sq.m. and a clamping pressure of 10.5 kg./sq.mm. are recommended for this test. The beam loading which corresponds to this higher clamping pressure closely approaches the breaking strength of the beams that have been furnished with the Z-S instrument. Hence, some precautions must be exercised to not exceed this higher clamping pressure.

## INTRODUCTION

In working with techniques aimed at the assessment of fiber strength, the zero-span test has been under investigation as mentioned in Progress Report One (1). Work with this test was initiated under preceding Projects 1513 and 2211 and proceeded with a zero-span (Z-S) instrument of Institute design. The development of this instrument is described in a publication (2) which, together with Report Five of Project 2211 (3), presents data showing the effect of several instrumental and sheet variables on the zero-span tensile result.

Since the issuance of Report Five, the Z-S instrument of Institute design has been used in the current program to explore two further variables. One deals with the dependence of the zero-span tensile result on the initial jaw separation (which is not actually zero-span for abutting jaw contact but involves finite jaw separations of several microns) and a related variable, fiber length. The other deals with the application of a tape liner to the jaw faces as described by Britt and Yiannos (4).

In working with long and short-fibered pulps and performing the zero-span test with the jaws separated by finite distances, the results given in Report Five indicated that the fiber length of a gumwood pulp, and possibly all short-fibered hardwood pulps, may be on the threshold of being too short for a valid measurement of zero-span tensile. In order to examine the validity of this test more closely with respect to the testing of short-fibered pulps, a gumwood pulp was classified into four fractions of different average fiber lengths. The fiber length distribution of each fraction was determined and each fraction was subsequently formed into handsheets for testing with the Z-S instrument at the initial and several additional finite jaw separations.

In working with the zero-span test, Britt and Yiannos found that the use of a tape liner on the four jaw faces minimized fiber damage of a regenerated cellulose fiber and resulted in significant increases in the zero-span tensile values for this material. This technique was examined in a preliminary way under the present program with the idea of determining whether similar beneficial effects could be achieved generally in the testing of a wide variety of pulps. In the course of this examination the effect of clamping pressure and basis weight on the zero-span result were determined for a limited number of different pulp hand-sheets.



## EFFECT OF INITIAL JAW SEPARATION AND FIBER LENGTH

## PROCEDURE

In order to explore more fully the effect of initial jaw separation and fiber length on zero-span tensile, a short-fibered gumwood bleached kraft pulp was classified into four fractions, formed into handsheets, and tested with the Z-S instrument, using the initial and additional finite jaw separations. The gumwood pulp was beaten in a Valley beater for 10 minutes prior to classification. Classification was done with a Bauer-McNett classifier, retaining as separate samples the fibers collected on 20, 35, 65, and 150-mesh screens. The percentage of fiber (by weight) retained on each screen was 12, 24, 39, and 20, respectively. Approximately 5% passed through the 150-mesh screen and was discarded. To characterize the four fractions the fiber length was determined with a Finnish semiautomatic fiber length recorder. For the fraction retained on the 150-mesh screen numerous ray cells were observed.

In preparation for forming the handsheets, approximately one gram of a given fraction was diluted with two liters of distilled water and disintegrated in a British disintegrator for 25,000 revolutions. A handsheet was then formed, pressed, and dried in accord with TAPPI Method T 205 m-58. This procedure was repeated to form the number of sheets required for the study. To characterize the handsheets thus formed the basis weight, thickness, density, and tensile strength were determined for each fraction.

To determine the effect of fiber length and initial jaw separation on zero-span tensile two Z-S instruments were used. One (No. 122) had an initial jaw separation of  $3.4 \mu$  (i.e., with opposing jaws butted together); with this instrument, the four fractions were measured for zero-span tensile by using the

initial jaw separation of  $3.4\ \mu$  and a finite separation of  $72\ \mu$ . The other instrument (No. 103) had an initial jaw separation of  $9\ \mu$  and measurements of the fractions were made by using the initial jaw separation of  $9\ \mu$  and additional finite separations of 25, 43, 80, and  $169\ \mu$ . For each measurement the specimen was cut to the exact width of the jaws and care was exercised to ensure alignment with the edges of the jaws. Each specimen was gripped at a clamping pressure of  $7.7\ \text{kg./sq. mm.}$  and tested at a rate of loading of  $4.0\ \text{kg. per (cm. sec.)}$ .

## RESULTS AND DISCUSSION

The results obtained for the purpose of characterizing the four fractions of gumwood pulp and the handsheets made from these fractions are given in Tables I and II, and Fig. 1. In Table I and Fig. 1 it will be seen that the four fractions of the pulp cover a fourfold range in average fiber length and that the weighted average fiber lengths for the four fractions are 1.62, 1.20, 0.88, and  $0.43\ \text{mm.}$  — a range that extends down to fiber lengths often encountered with hardwood pulps.

The zero-span tensile results obtained for the four fractions of gumwood when tested at the initial and finite jaw separations are given in Table III and Fig. 2. These results show, as did the results previously obtained for a gumwood whole pulp and longer fibered pulps (3), that the zero-span tensile becomes increasingly more dependent on jaw separation as the fiber length decreases. For the two longer fibered fractions, having weighted average fiber lengths of 1.62 and  $1.20\ \text{mm.}$ , jaw separations up to about  $80\ \mu$  can be tolerated without significantly altering the result. Similarly, the fraction having a weighted average fiber length of  $0.88\ \text{mm.}$  can tolerate jaw separations up to about  $40\ \mu$ , whereas it would appear that the fraction having a weighted average fiber length of  $0.43\ \text{mm.}$  can only tolerate a jaw separation up to about  $9\ \mu$ . The results for these four fractions,

TABLE I

THE FREQUENCY AND AVERAGE FIBER LENGTH OF FOUR FRACTIONS  
OF GUMWOOD BLEACHED KRAFT PULP

Interval, mm.	(b) Average Length, mm.	(a) Frequency, %			
		Fraction on Screen 20	Fraction on Screen 35	Fraction on Screen 65	Fraction on Screen 150
0.0-0.1	0.05	--	--	0.3	2.4
0.1-0.2	0.15	--	--	0.9	7.2
0.2-0.4	0.3	0.7	0.8	10.2	58.3
0.4-0.6	0.5	0.9	3.2	25.3	25.9
0.6-0.8	0.7	2.2	12.0	22.4	4.4
0.8-1.0	0.9	5.8	16.9	20.1	1.3
1.0-1.2	1.1	11.2	20.9	10.8	0.5
1.2-1.4	1.3	22.6	32.2	7.6	--
1.4-1.6	1.5	21.8	9.5	2.1	--
1.6-1.8	1.7	14.8	3.7	0.3	--
1.8-2.0	1.9	8.1	0.6	--	--
2.0-2.2	2.1	7.4	0.1	--	--
2.2-2.4	2.3	2.0	--	--	--
2.4-2.6	2.5	1.1	0.1	--	--
2.6-2.8	2.7	0.1	--	--	--
2.8-3.0	2.9	0.4	--	--	--
3.0-3.2	3.1	0.1	--	--	--
3.2-3.4	3.3	0.2	--	--	--
3.4-3.6	3.5	0.4	--	--	--
3.6-3.8	3.7	--	--	--	--
3.8-4.0	3.9	0.2	--	--	--
Average fiber length					
Arithmetic = $\Sigma ab/100 =$		1.49	1.12	0.75	0.36
Weighted = $\Sigma ab^2/\Sigma ab =$		1.62	1.20	0.88	0.43

TABLE II

PHYSICAL PROPERTIES OF HANDSHEETS PREPARED FROM  
FOUR FRACTIONS OF GUMWOOD BLEACHED KRAFT PULP

Property	Weighted Average Fiber Length of Fraction, mm.			
	1.62	1.20	0.88	0.43
Basis weight, g./sq.m.	56.6	53.2	54.8	54.4
Thickness, $\mu$	108	102	97	86
Density, g./cc.	0.48	0.52	0.57	0.63
Tensile breaking length, km.	2.37	2.38	2.35	2.62

For basis weight and tensile breaking length each value represents the average of only two determinations and for thickness the average of five determinations.

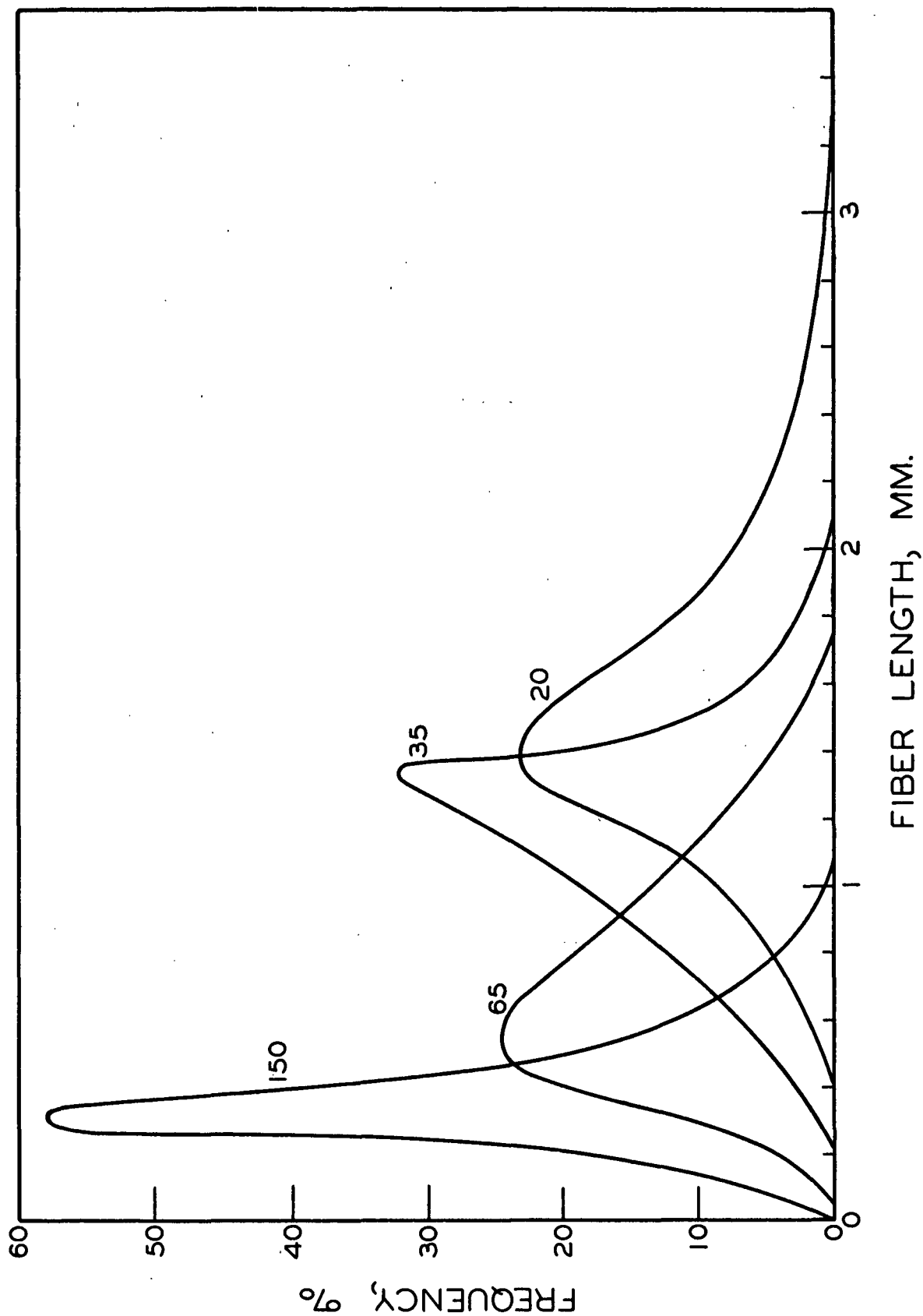


Figure 1. Fiber Length Distribution of Four Fractions of Gunwood Bleached Kraft Pulp Retained on 20, 35, 65, and 150-Mesh Screens

TABLE III

THE EFFECT OF FINITE JAW SEPARATIONS ON  
"ZERO-SPAN" TENSILE FOR FOUR FRACTIONS OF GUM-  
WOOD BLEACHED KRAFT PULP

Jaw Separation, $\mu$	Zero-Span Breaking Length, km.			
	Weighted Average Fiber Length of Fraction, mm.			
	1.62	1.20	0.88	0.43
3.4 <sup>a</sup>	14.7 $\pm$ 0.22	14.2 $\pm$ 0.17	13.0 $\pm$ 0.10	11.4 $\pm$ 0.10
9.0 <sup>b</sup>	14.7 $\pm$ 0.23	14.4 $\pm$ 0.22	13.1 $\pm$ 0.10	11.4 $\pm$ 0.10
25 <sup>b</sup>	14.7 $\pm$ 0.22	14.0 $\pm$ 0.20	12.7 $\pm$ 0.18	11.0 $\pm$ 0.07
43 <sup>b</sup>	14.2 $\pm$ 0.22	14.2 $\pm$ 0.20	13.0 $\pm$ 0.13	10.8 $\pm$ 0.10
72 <sup>a</sup>	14.2 $\pm$ 0.17	14.0 $\pm$ 0.22	12.4 $\pm$ 0.10	10.3 $\pm$ 0.12
80 <sup>b</sup>	14.0 $\pm$ 0.17	14.1 $\pm$ 0.22	12.4 $\pm$ 0.10	10.2 $\pm$ 0.12
169 <sup>b</sup>	13.0 $\pm$ 0.20	13.2 $\pm$ 0.17	11.6 $\pm$ 0.17	9.0 $\pm$ 0.08

<sup>a</sup>Jaw 122 having initial jaw separation of 3.4  $\mu$ .

<sup>b</sup>Jaw 103 having initial jaw separation of 9  $\mu$ .

Each value represents an average of 25 determinations. The standard errors are given.

especially for the shortest fraction, give an indication of the critical nature of the zero-span test for the testing of short-fibered pulps, the close tolerances that are required for jaw construction, and the important need for keeping the abutting jaw surfaces free of debris to insure proper closure of opposing jaws. Judging from these results there is a potential danger of obtaining invalid results if the fibers comprising the test specimen are short. Consequently, in order to proceed with some confidence in the application of this test to short-fibered pulps, the initial jaw separation must be known and the jaws must be maintained clean and in proper alignment at all times.

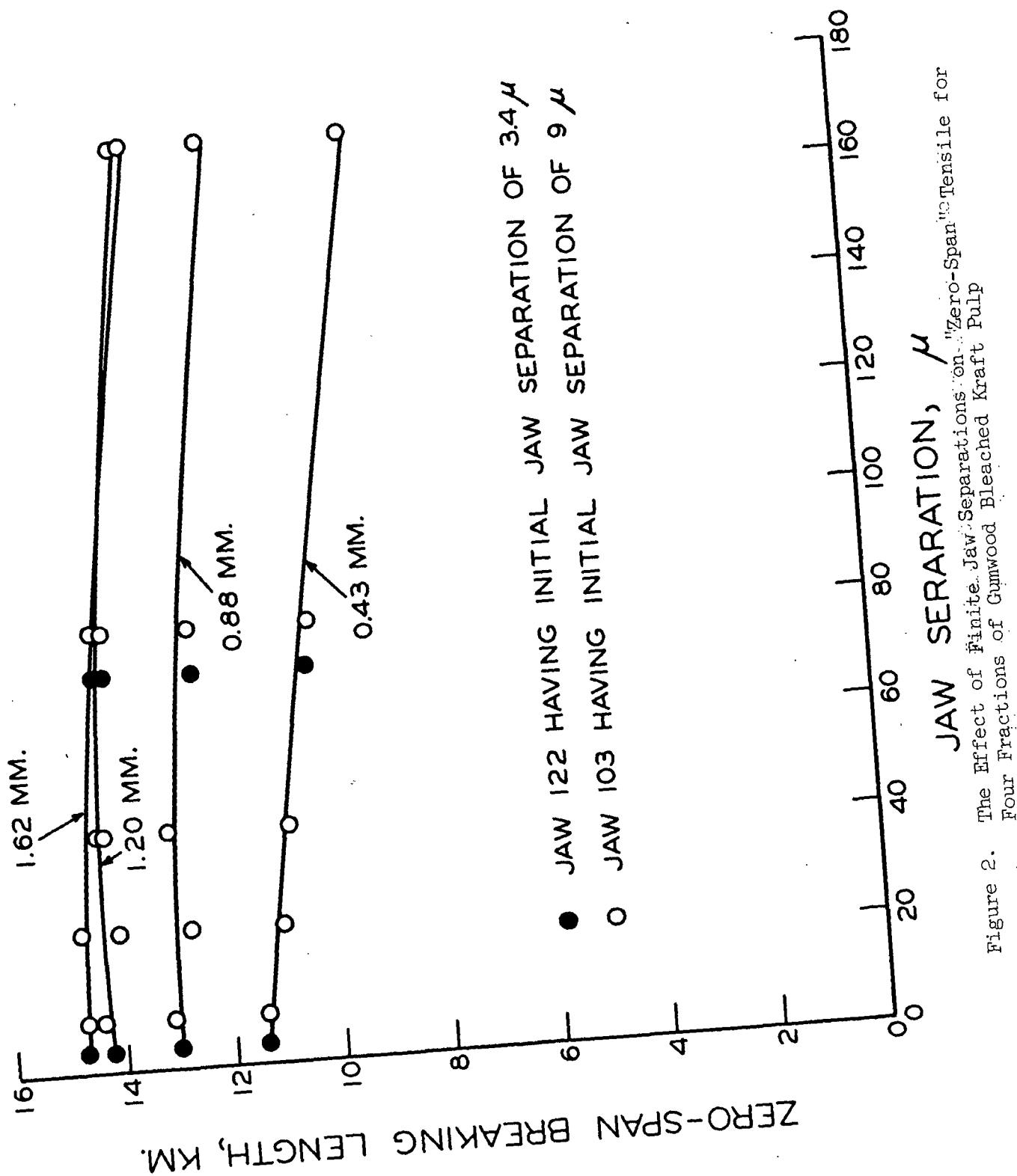


Figure 2. The Effect of Finite Jaw Separations on "Zero-Span" Tensile for Four Fractions of Gumwood Bleached Kraft Pulp

## EFFECT OF TAPE CUSHION IN THE JAWS

## PRELIMINARY OBSERVATIONS

A preliminary study was made to determine what effect the application of the Britt-Yiannos technique of lining the jaw gripping surfaces with a Scotch cellophane tape No. 600 might have on zero-span tensile results determined with the Z-S instrument of Institute design. In order to investigate this effect with a wide variety of materials, without excessive expenditure of time, these first trials were made using the machine-made paper previously used in zero-span testing, and handsheets submitted by other projects for routine testing of zero-span. The test conditions chosen for this preliminary study were those previously found to be optimum for performing the zero-span tensile test with the bare unlined jaws. Accordingly, the zero-span tests were performed by using a clamping pressure of 7.7 kg./sq.mm., a rate of loading of 4.0 kg. per (cm. sec.) and handsheets having a basis weight lying in the range of 40 to 55 g./sq.m. (2, 3).

For the first two of the samples the zero-span tensile tests were made with (a) the bare unlined jaws, (b) one jaw face of opposing pairs lined with the tape for contact with one side of the specimen, and (c) all four jaw faces lined with the tape. The adhesive side of the tape in all cases faced the metal. In the case of one sample consisting of a western hemlock kraft handsheet, zero-span breaking length values of 21.7, 24.0, and 23.0 km. were obtained for jaw gripping conditions (a), (b), and (c), respectively. In the case of the other sample, consisting of a machine-made 100% rag paper and tested in the machine direction, excessive slippage was observed to occur for jaw gripping condition (c).

Mainly because of the slippage observed for condition (c), the remaining samples used in this preliminary study were tested with jaw gripping conditions (a)

and (b) only. Briefly, the results for these showed that condition (a) yielded higher zero-span values than condition (b) for samples having a high breaking load, whereas condition (b) yielded higher zero-span values than condition (a) for samples having a low breaking load.

These results suggested several possibilities, including: (1) that the clamping pressure of 7.7 kg./sq.mm., previously found to be optimum for the bare jaw condition (a), may have been too low for secure gripping of the specimens when tested with the tape-lined jaw in accord with condition (b), and (2) that the basis weights of the handsheets, optimum for condition (a), may have been too high to achieve secure gripping of the specimens when the test is performed with a tape lining in the jaws in accord with condition (b).

#### PROCEDURE

In order to explore these two possibilities more fully, a study was made to determine the effect of clamping pressure and basis weight on zero-span tensile when performing the test with and without the tape in accord with jaw gripping conditions (a) and (b). For this study seven samples were selected from those used in the preliminary study; these, in the preliminary study exhibited the largest differences in the zero-span tensile values obtained with jaw gripping conditions (a) and (b). One was the machine-made 100% rag paper and the others were handsheets prepared from six different pulps yielding different strength levels. For the study on clamping pressure the handsheets were prepared and formed as described in an earlier section of this report. For the study on basis weight two pulps were used (the two which displayed the greatest and smallest dependence of zero-span tensile on clamping pressure) and the handsheets, except for amount of material, were prepared and formed as described earlier.



For the zero-span tests performed in accord with jaw gripping condition (b) the jaw faces were lined with the tape as follows: With the opposing jaw pairs separated in the direction of increasing test span, the tape was inserted between the jaw gripping surfaces with the adhesive side facing the 0.60-mm. wide surface, and clamped at a clamping pressure corresponding to that subsequently used for the zero-span test. The tape was then cut and one of the jaw pairs loosened and removed from the base plate of the instrument assembly. Using a new and sharp razor blade, the protruding tape around the jaw edges was trimmed off and care was exercised to ensure that all the protruding tape was removed. The clamping pressure was then released and the instrument reassembled in preparation for testing. In performing the test with the tape, a piece of tape was placed over the two leveling specimens before inserting these in the Z-S instrument. Otherwise, the zero-span tests with and without tape were performed in the same way.

Although experience indicated that a given tape liner may be used for 10 or more tests without apparent adverse effects, the tape liners for the purposes of this study were changed after every five tests. For every new pair of tape liners inserted in the jaws, a new razor blade was used for trimming the tape. Following a series of 5 measurements, it has been found that the tape liners are easily removed with a dissecting needle. The needle is inserted between the tape and the relieved metal surface behind the 0.60-mm. surface and turned to lift the tape away from the jaw surface.

#### EFFECT OF CLAMPING PRESSURE

Zero-span breaking lengths obtained for the seven samples at several clamping pressures with and without the tape in the jaws are given in Table IV and Fig. 3 to 9. (The clamping pressures of 12.3 and 14.1 kg./sq.mm. were

TABLE IV

THE EFFECT OF CLAMPING PRESSURE ON ZERO-SPAN TENSILE  
WITH AND WITHOUT A CELLOPHANE TAPE ON ONE FACE OF EACH PAIR OF JAWS

Sample	Description <sup>a</sup>	Clamping Condition	Basis Wt., g./sq.m.	Observed Zero-Span Breaking Load, lb./15 mm. <sup>b</sup>	Zero-Span Breaking Length, km.			Significant Difference at 95% Confidence Level	
					7.7	9.1	10.5	12.3	14.1
1	Rag 100%, M.D.	Without tape With tape	70 70	40 --	17.5 17.0	17.6 17.4	17.5 17.9	-- 18.6	-- 18.1
2	Western softwood bleached sulfite	Without tape With tape	51 51	26 --	15.0 16.0	14.0 15.9	15.1 15.8	-- 15.3	-- 16.2
3	Western hemlock kraft	Without tape With tape	40 40	32 --	21.4 23.9	21.6 25.0	21.2 24.3	-- 25.6	-- 24.6
4	Aspen	Without tape With tape	50 50	37 --	22.3 20.7	21.2 22.2	22.0 22.2	-- 23.7	-- 22.4
5	Black spruce	Without tape With tape	51 51	31 --	17.8 18.8	17.5 19.0	17.8 18.8	-- 19.6	-- 18.6
6	White oak	Without tape With tape	49 49	29 --	17.3 18.8	17.4 18.1	17.8 18.2	-- 19.3	-- 18.6
7	Aspen	Without tape With tape	48 48	36 --	23.0 20.5	22.8 22.0	22.4 23.4	-- 23.8	-- 22.8

*Ratio*  
0.946  
0.932  
0.844  
0.941  
0.908  
0.911  
0.966

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<sup>a</sup> Sample 1 was a machine-made paper and tested in the machine direction; Samples 2-7 were handsheets prepared in accord with TAPPI Method T 205 m-58.  
<sup>b</sup> The observed breaking load at a clamping pressure of 7.7 kg./sq.mm. for specimens having basis weights given in Column 4.  
Each zero-span value represents an average of ten determinations.

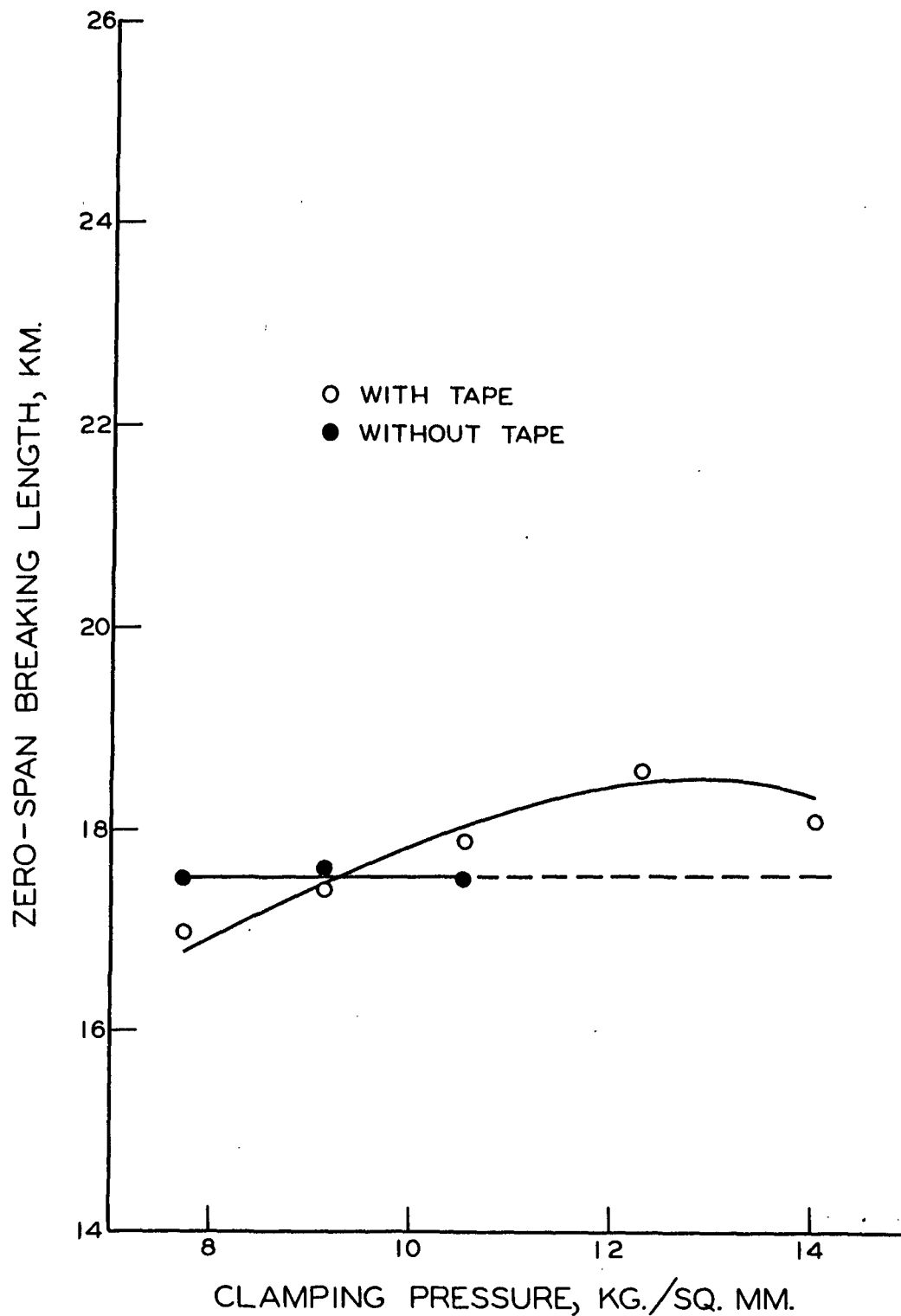


Figure 3. The Effect of Clamping Pressure on Zero-Span Tensile for Sample 1, 100% Rag, Machine Direction, with and without a Cellophane Tape on One Face of Each Pair of Jaws

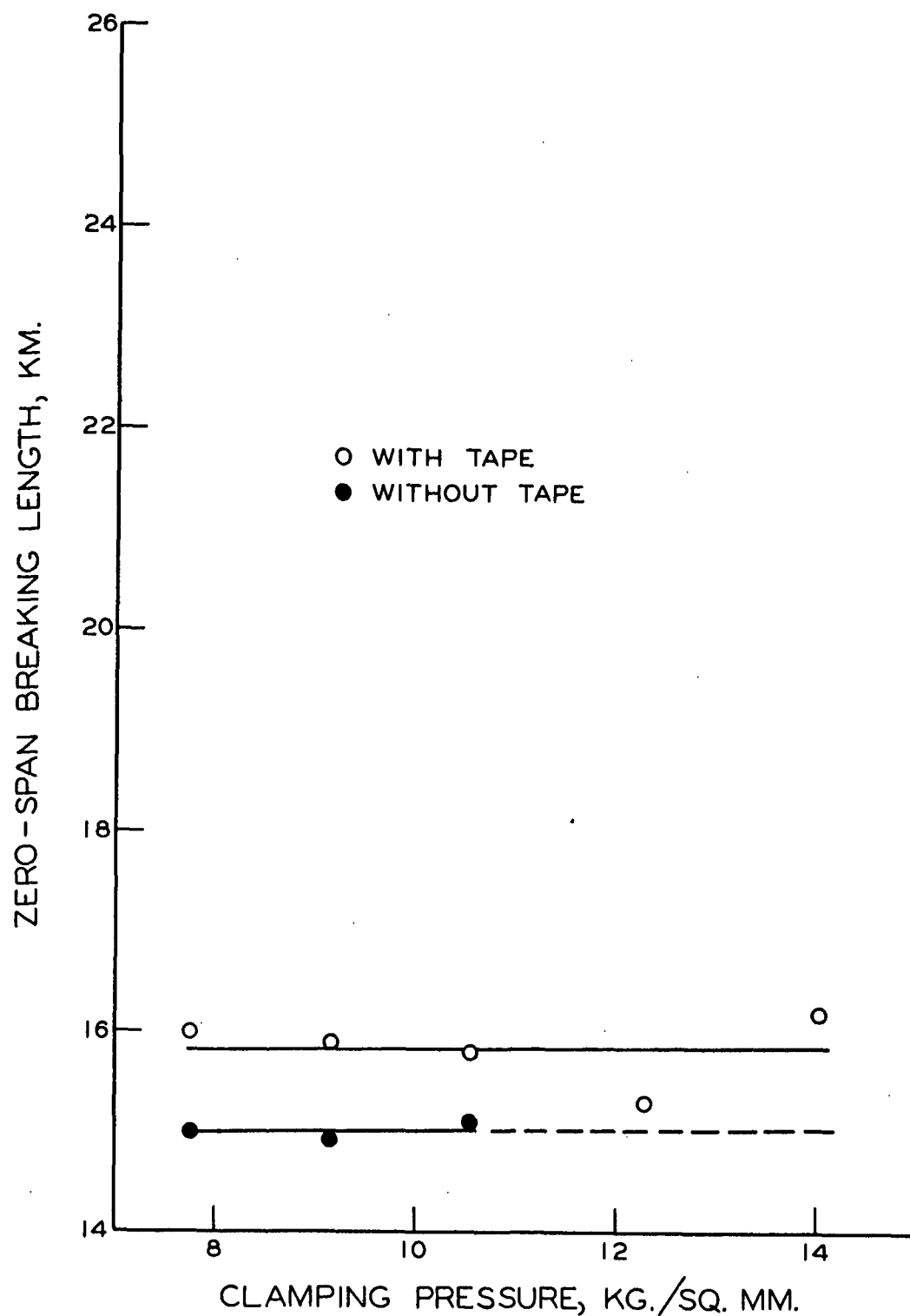


Figure 4. The Effect of Clamping Pressure on Zero-Span Tensile for Sample 2, Western Softwood Bleached Sulfite, with and without a Cellophane Tape on One Face of Each Pair of Jaws

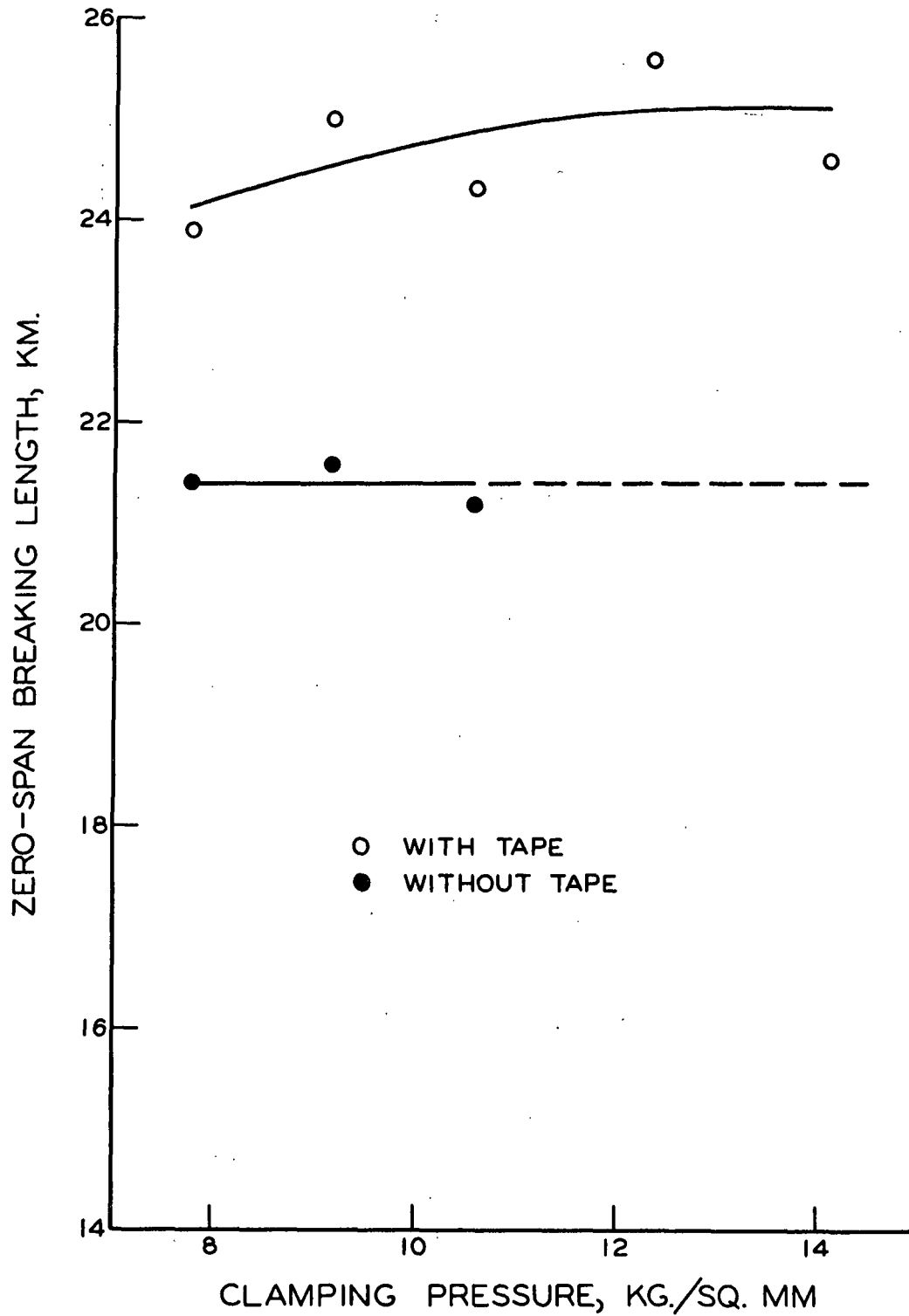


Figure 5. The Effect of Clamping Pressure on Zero-Span Tensile for Sample 3, Western Hemlock Kraft, with and without a Cellophane Tape on One Face of Each Pair of Jaws

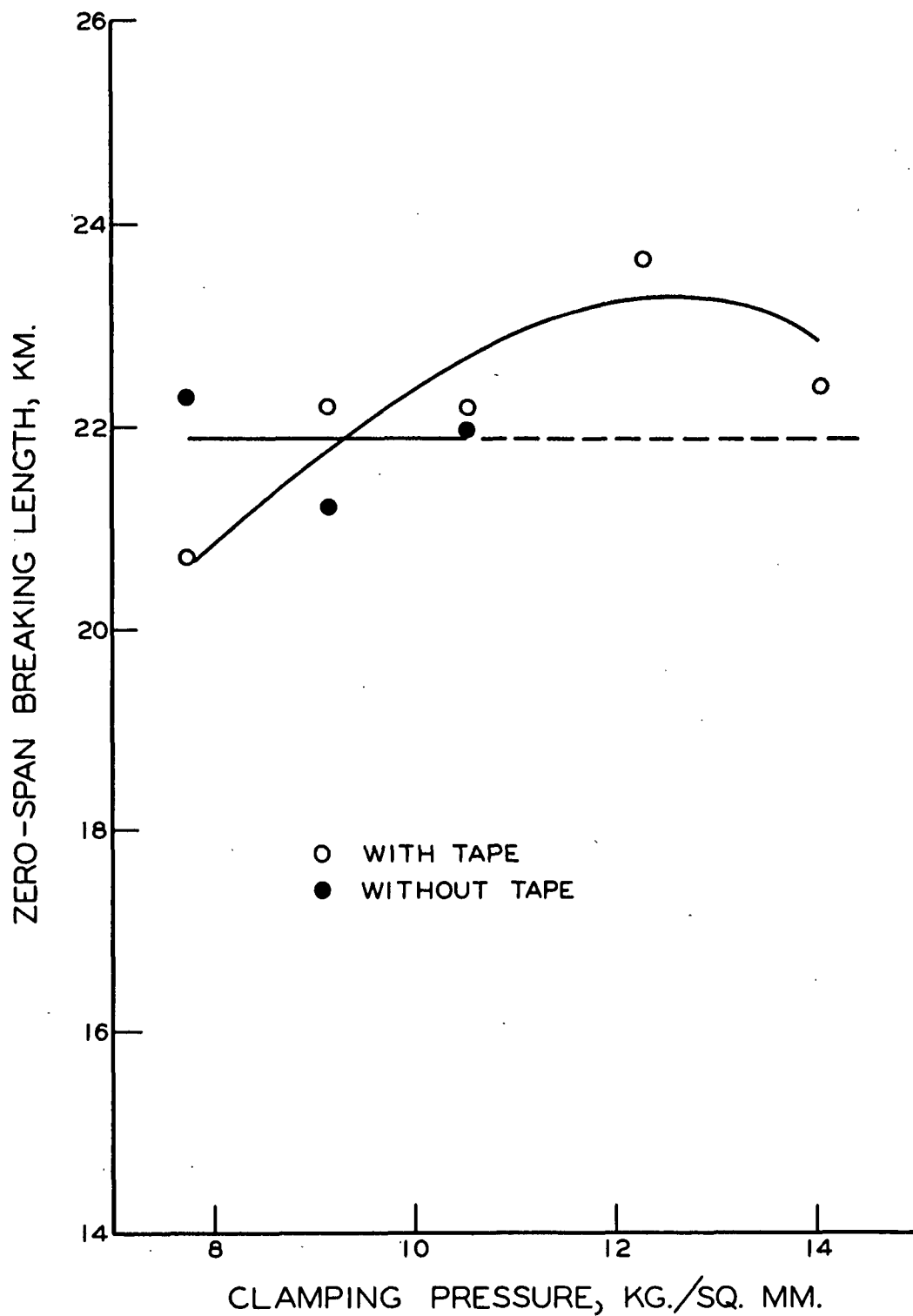


Figure 6. The Effect of Clamping Pressure on Zero-Span Tensile for Sample 4, Aspen, with and without a Cellophane Tape on One Face of Each Pair of Jaws

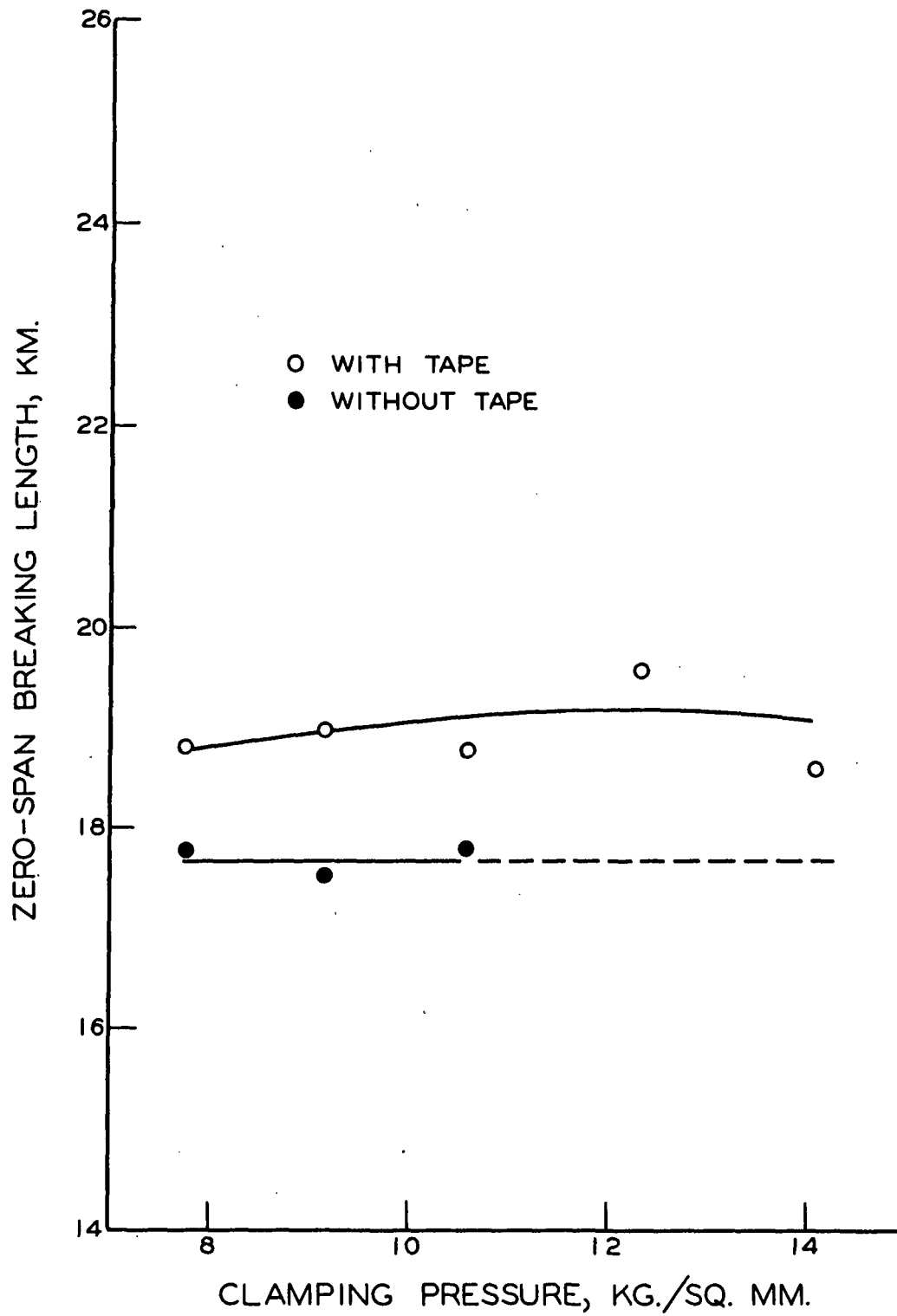


Figure 7. The Effect of Clamping Pressure on Zero-Span Tensile for Sample 5, Black Spruce, with and without a Cellophane Tape on One Face of Each Pair of Jaws

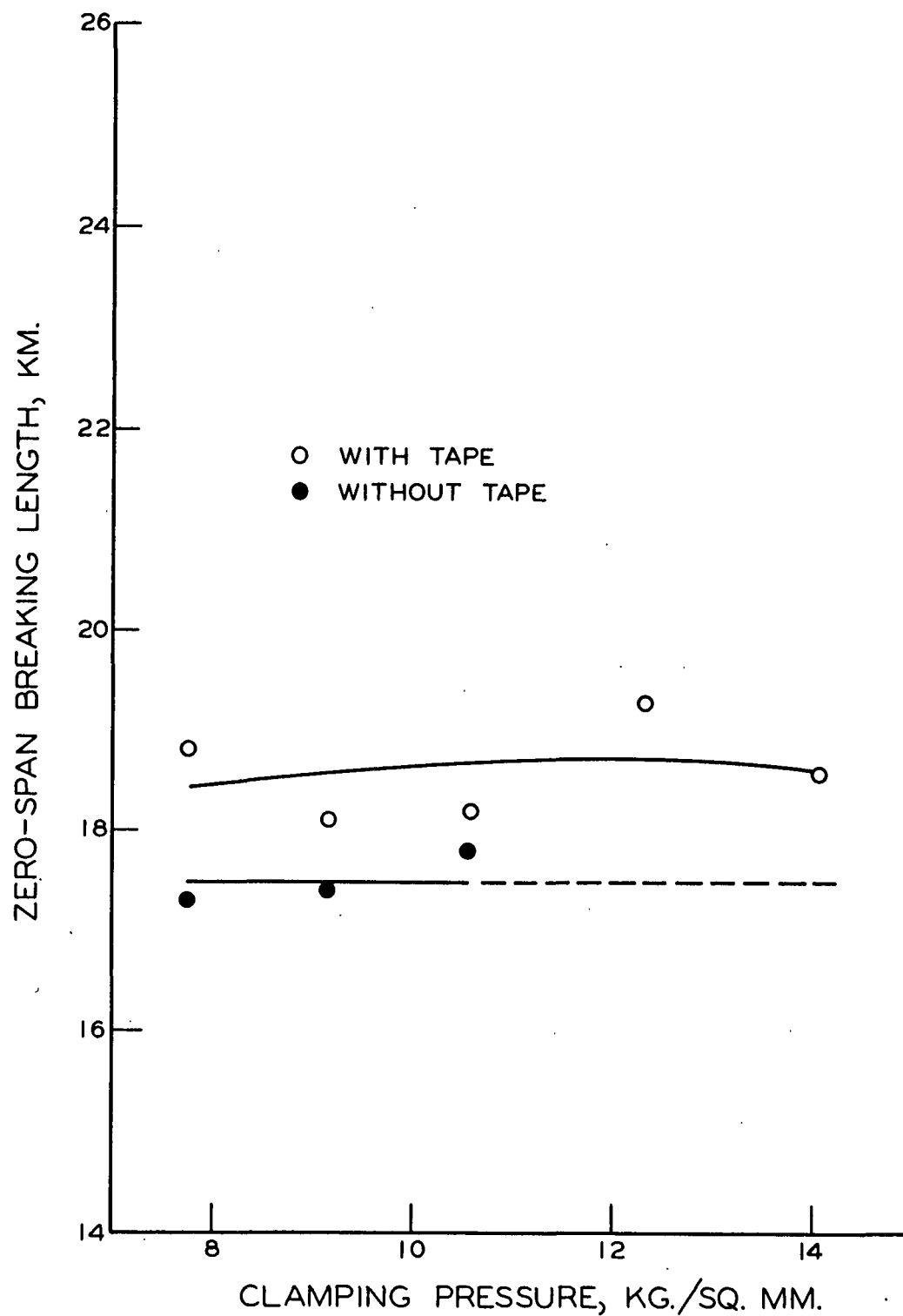


Figure 8. The Effect of Clamping Pressure on Zero-Span Tensile for Sample 6, White Oak, with and without a Cellophane Tape on One Face of Each Pair of Jaws



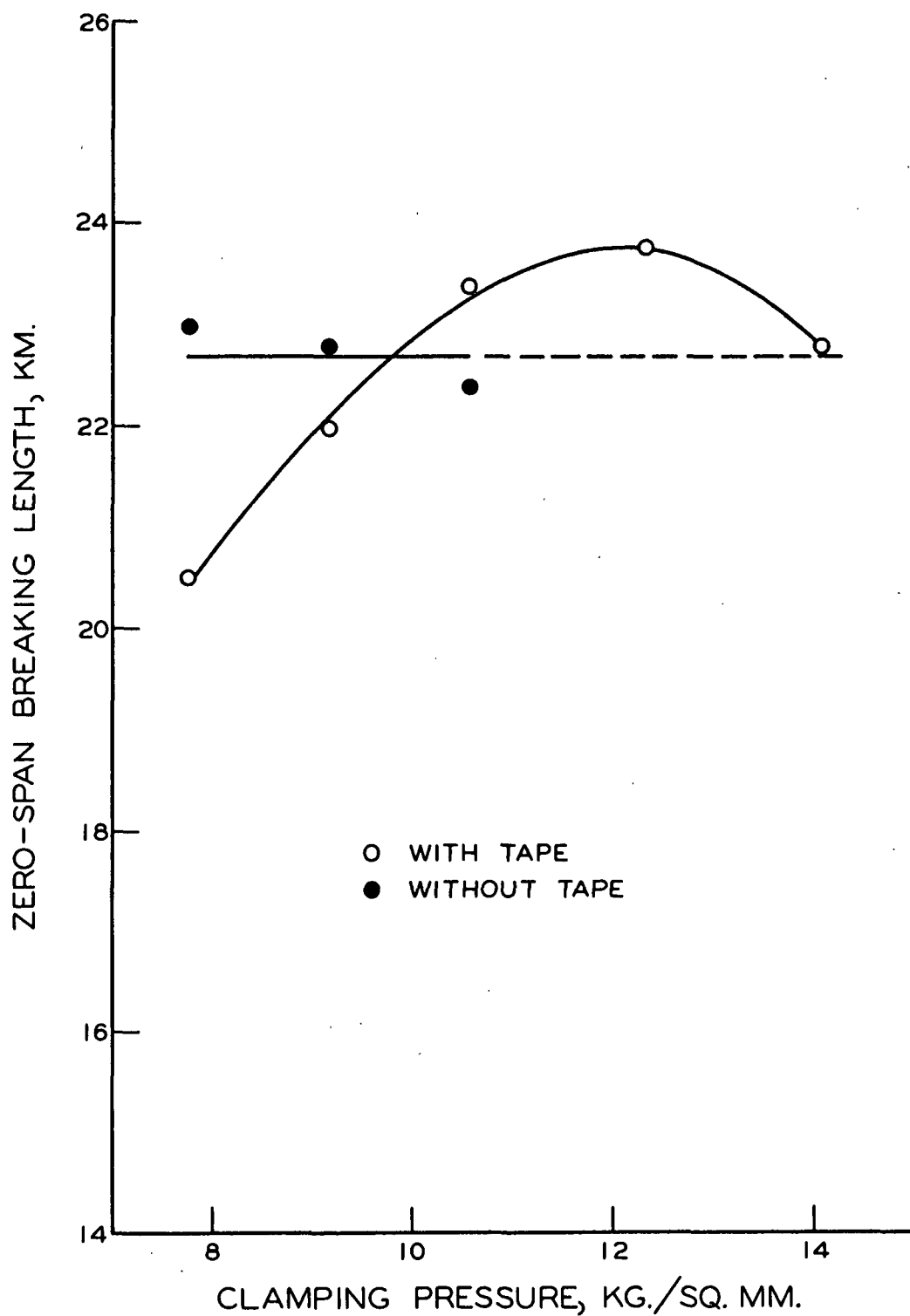


Figure 9. The Effect of Clamping Pressure on Zero-Span Tensile for Sample 7, Aspen, with and without a Cellophane Tape on One Face of Each Pair of Jaws

obtained with loading beams heavier than those normally furnished with this Z-S instrument.) In the figures the dashed lines represent an extrapolation of the results obtained with the bare jaws. Justification for this extrapolation is based on earlier work (2) which has shown that the zero-span tensile result determined with the bare jaw is independent of clamping pressure in the range of 6.5 to 13.1 kg./sq.mm.

On examination of the results obtained with the tape it will be seen that the manner in which the clamping pressure affects the zero-span breaking length (as calculated to eliminate basis weight) depends on the magnitude of the observed breaking load. For the lower observed breaking loads of Samples 2, 3, 5, and 6 (26, 32, 31, and 29 lb./15 mm., respectively), the zero-span breaking lengths are seen to be comparatively independent of clamping pressure. For the higher observed breaking loads of Samples 1, 4, and 7 (40, 37, and 36 lb./15 mm., respectively) the zero-span tensile breaking lengths obtained with the tape are seen to increase with increasing clamping pressure up to pressures of 12-13 kg./sq.mm. Above this optimum clamping pressure range all samples, except Sample 2, show a decrease in the zero-span breaking length. At the optimum pressure for both jaw gripping conditions the highest zero-span breaking lengths were obtained for all samples when tested with the tape liner in the jaws.

The higher zero-span values obtained with the tape are attributed to a more uniform distribution of the clamping load on the specimen and, hence, enhanced gripping of all fibers involved in the test. Further evidence of improved gripping achieved with the tape was observed visually and recorded photographically. The photographs in Fig. 10 show the fractured zone of tested specimens of Sample 3; this sample displayed the largest increase in zero-span breaking length on going from the bare to the tape-lined jaws; and, on the basis of our visual examination,

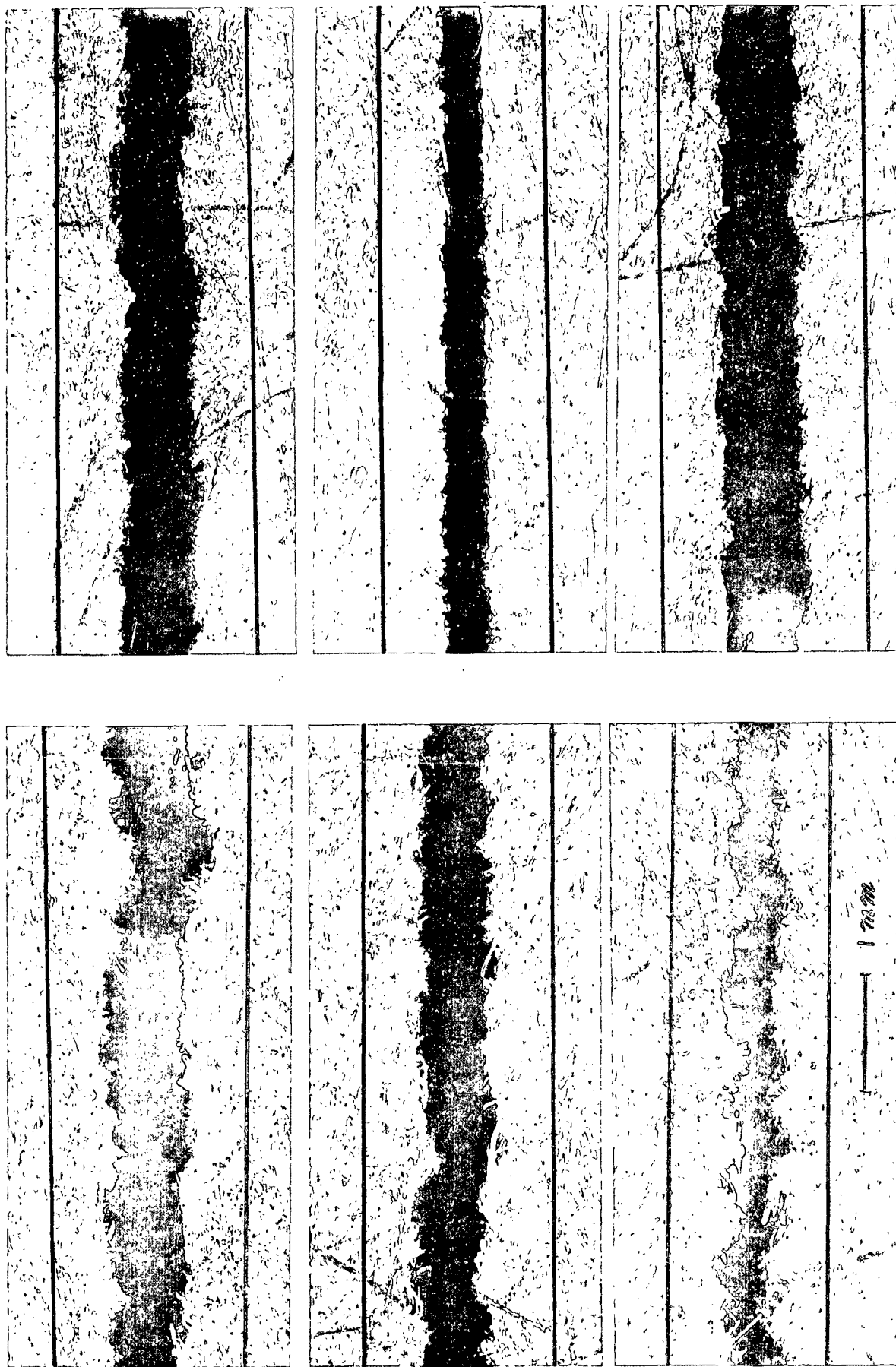


Figure 10. Photographs Showing the Zone of Fracture that Resulted in the Zero-Span Testing of Sample 3, Western Hemlock Kraft. Those on the Left are for Specimens Tested without the Cellophane Tape in the Jaws; Those on the Right are for Specimens Tested with the Tape. Magnification 20X

exhibited the poorest formation among the seven samples. In comparing the photographs of the fractured zones obtained with and without the tape, it will be seen that the zone of fracture obtained with the tape is more regular than that obtained without the tape. The handsheets for this sample contained a small percentage of dyed fibers which are visible in the photographs.

#### EFFECT OF BASIS WEIGHT

The results showing the dependence of zero-span breaking length on basis weight for measurements made on Samples 2 and 7 at a clamping pressure of 7.7 kg./sq.mm. without the tape and at clamping pressures of 7.7 and 10.5 kg./sq.mm. with the tape are given in Table V and Fig. 11. It may be seen first of all that the zero-span breaking lengths determined without the tape are in agreement with earlier studies (2,3) which showed a maximum at basis weights in the range of 40 to 55 g./sq.m. and tended to fall off in value below this range. In contrast to this behavior the zero-span breaking lengths determined with the tape increase mildly with decreasing basis weight for the weaker Sample 2 and more strongly for the stronger Sample 7.

While the results obtained with the tape for Sample 7 indicate that the dependence of zero-span breaking length on basis weight may be reduced by increasing the clamping pressure, the results shown in Fig. 9 for a 48 g./sq.m. sheet of the same sample indicate that an increase in clamping pressure at this basis weight may not significantly increase the result. Hence, in performing this test with the tape, it would appear that the basis weight of the test specimens will need to be controlled within a narrow weight range in order to obtain a meaningful comparison of the zero-span tensile strength of pulps, at least for high-strength pulps.

TABLE V

THE EFFECT OF BASIS WEIGHT ON ZERO-SPAN TENSILE  
WITH AND WITHOUT A CELLOPHANE TAPE ON ONE FACE OF EACH PAIR  
OF JAWS AND AT TWO LEVELS OF CLAMPING PRESSURE

Basis Weight, g./sq.m.	Zero-Span Breaking Length, km.		
	Without Tape	With Tape	
	Clamping Pressure, kg./sq.mm.		
	7.7	7.7	10.5
Sample 2, Western softwood bleached sulfite			
12.0	14.8	16.7	17.4
24.6	15.3	17.5	17.2
35.5	15.4	16.6	17.2
48.5	15.5	16.2	16.3
59.0	15.2	15.6	16.2
Sample 7, Aspen			
12.6 <sup>a</sup>	20.7	27.2	29.4
12.6 <sup>a</sup>	--	--	26.5
12.6 <sup>a</sup>	--	--	27.5
26.0	23.3	25.9	27.0
40.0	22.0	22.3	24.8
51.6	23.9	20.9	23.8

<sup>a</sup>These handsheets were formed on different days.

Each zero-span value represents an average of 10 determinations.

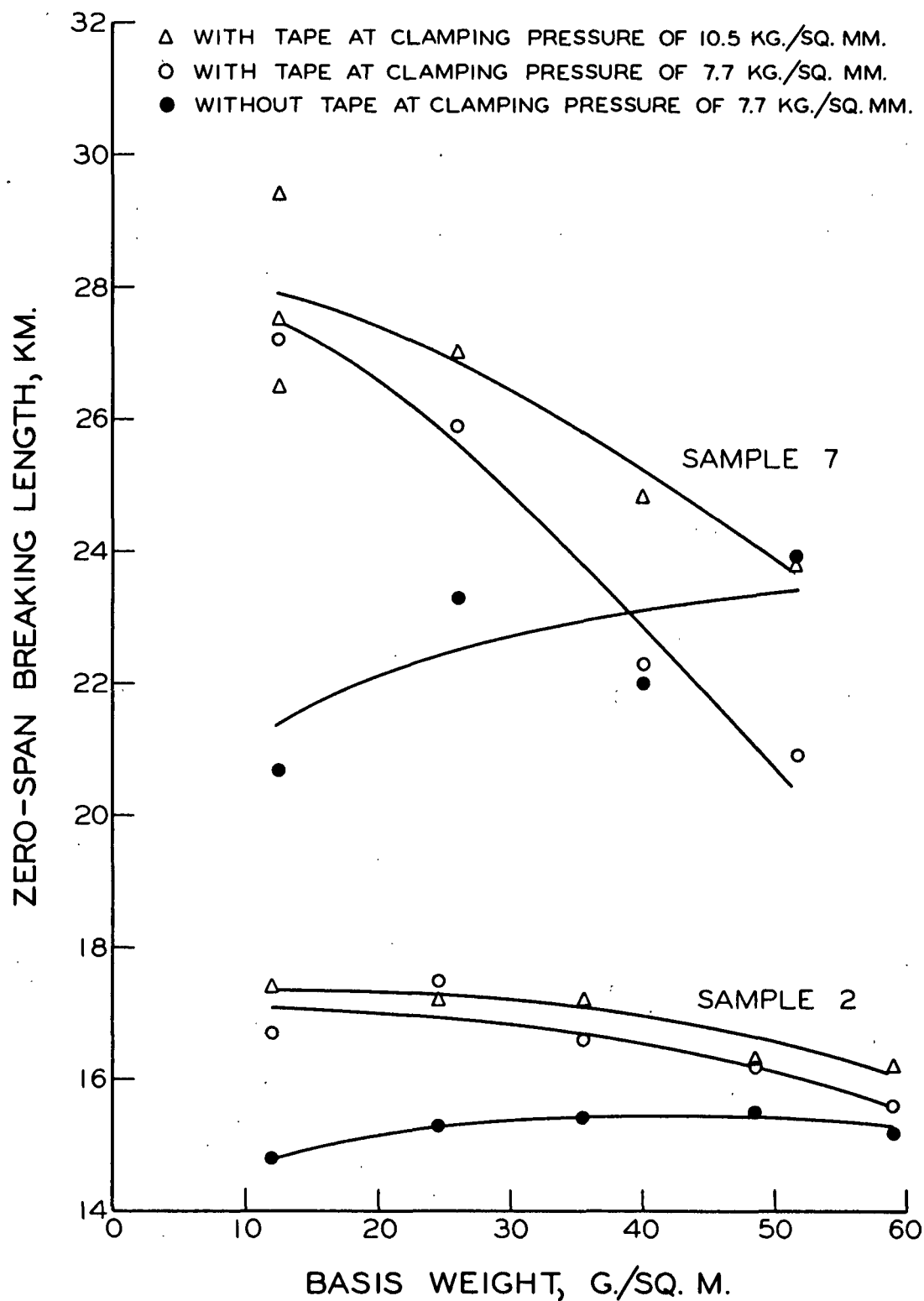


Figure 11. The Effect of Basis Weight on Zero-Span Tensile for Samples 2 and 7, with and without a Cellophane Tape on One Face of Each Pair of Jaws at Two Levels of Clamping Pressure

## GENERAL COMMENTS

If we judge the progress that has been made in the development of the zero-span test on the basis of achieving maximum values, then this work, as well as that of Britt and Yiannos, indicates that the use of a tape liner represents a significant improvement in procedure. The use of the tape apparently results in improved gripping conditions and appears to minimize the adverse effects of handsheet formation on the result. Handsheets having the poorest formation in this study displayed the greatest increases in zero-span tensile on going from the bare to the tape-lined jaws. At the moment it is not known whether handsheets of adequately good formation could be formed to achieve bare-jaw results comparable to those achievable with the tape-lined jaws.

Tentatively, the tape appears to offer the best opportunity of achieving the highest and more valid zero-span result for a given pulp. However, in the use of the tape, it is important to control the basis weight of the handsheets within narrow limits and, judging from our experiences, to exercise great care in trimming the tape along the leading edges of the jaws. This trimming requires good operator judgment; any protruding tape would prevent proper closure of the jaws and would constitute a potential source of error.

The selection of a suitable basis weight for performing this test with a tape is by necessity arbitrary. The results of this study showed that the basis weight should be as low as possible whereas, on the other hand, it also showed that the reproducibility falls off sharply for basis weights in the vicinity of and below 12 g./sq.m. Upon taking these two effects into account, along with the other factors which have been found to contribute to the result, it seems reasonable to conclude and recommend that this test be performed henceforth with

handsheets having a basis weight of 20 g./sq.m., with tape-lined jaws\*, and at a clamping pressure of 10.5 kg./sq.mm. (This clamping pressure, it should be recognized, is higher than that formerly used with the bare jaws. The beam loading required to achieve this higher clamping pressure closely approaches the beam breaking strength. Accordingly, care must be exercised to avoid overloading the beams presently supplied with the Z-S instrument, or heavier beams should be installed.) By using this sheet weight and procedure, preliminary results obtained in the testing of early and latewood Douglas-fir indicated fairly good agreement between the average individual fiber breaking stress and breaking stress computed from the zero-span result.

The performance of a tape-lined jaw with respect to the effect of fiber length has not been studied. However, we would anticipate that the results obtained with the tape for a short-fibered pulp may be nearly as critically dependent on initial jaw separation as was found with the bare jaw. Hence, it seems reasonable to assume that the need for knowing the initial jaw separation and for maintaining the jaws clean and in proper alignment at all times is as important with the tape-lined jaws as with the bare jaws.

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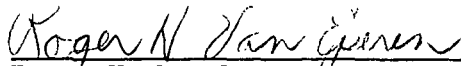
\*One face of each jaw pair lined with tape.



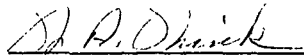
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